METHOD OF CONVERTING DIGITAL DATA

BACKGROUND OF THE INVENTION

.5   1. Field of the invention

The present invention relates to a method of modulation and demodulation for recording digital data to a recording or reproducing medium that can record or reproduce the digital data.   In particular, the present invention relates to a method of data conversion suitable for recording the digital data to an optical record medium in

10   high or low density, a method of record reproduction using the same, and an optical record medium recorded with the modulated data.

2. Description of the prior art

A method of EFM (8/17 modulation) coding is provided as a method for

15   recording digital data through encoding.   A method of digital data modulation such as EFM or EFM plus is applied to record data, in particular, to an optical record medium or disk including CD, CD-R, CD-RW, DVD and so on.

In recording the digital data to a recording medium such as optical record medium, a recording capacity is an important item to be considered.   In other words,

20   since the same disk can contain more information when information is recorded in high density, a recording density of digital data is determined according to the method of modulation.

The EFM code in use for recording the digital data on a CD-type optical record medium has a Run Length Limited (RLL), in which d is 2 and k is 10, and a code rate

25   corresponding to R=8/17.   Referring to a coding method using the EFM code, an eight

bit source code is converted to a fourteen bit d-restraint code word, which is attached with a three bit merging word. The three bit merging word is selected by an encoder to satisfy the minimum and maximum run lengths, the inherent codes for satisfying the maximum and minimum run lengths are not uniquely determined. Further, the merging word is selected so that power density is minimized in low frequency.

Fig. 1 shows an example of a merging processor, in which eight user data bits are converted to fourteen channel bits using a look-up table, and to the end of the fourteen bits is attached with a merging bit satisfying three run length limitations.

Since two zeros are necessarily present between two ones, '0' is necessarily present in the first merging bit position in the foregoing situation. Therefore, the merging bits can exist in three cases such as 000, 010 and 001. In this case, the encoder is adapted to select a merging bit having the lowest absolute value for a Running Digital Sum (RDS) at the end of a new code word, and accordingly 000 in the above situation. In an experiment about CD, when only two merging bits are used, compression of low frequency components (DC compression) is not sufficiently efficient. Therefore, when the number of merging bits is increased to three, margin of transition setting or omission in the merging bits is increased more.

In general, a good method of compression about the low frequency components by a compensated merging method without providing a certain standard about a CD system. For example, compression can be executed through a look-ahead method since the minimization about the low frequency components in a short term does not always influence the minimization in a longer term. In this case, it is reported that performance improvement of 6 to 10dB is obtained.

Meanwhile, the EFM plus code used in DVDs is a sliding block code capable of restraining the low frequency components in which the code rate is 8/16 and the RLL is

(2, 10). The EFM plus code, which has the code rate higher than the previous EFM code about 6% as an advantage, is re-designed from the EFM code by replacing the 8/17 code rate with the 8/16 code rate and has the two merging bits instead of the merging bits of three bit.

5   As described hereinbefore, the CD, CD-ROM, CD-V and the like are proposed as very successful media for storing MPEG video data and other various digital information. However, the storage capacity of about 680 Mbytes is not sufficient for the operation of a graphic-based computer or to store high-definition digital video programs. A DVD, which can be an expansion of the CDs, is a novel optical record
10   medium with a storage capacity of at least 7 times of a typical CD. The increase of storage capacity is made through the quality elevation of a light source and an object lens. Besides, the storage capacity of the DVD is increased by totally re-designing a logical mode of the disk through use of more enhanced RS-PC and a record code called the EFM plus, in which the EFM plus has a code rate of 8/16 with (d,k)=(2,10) and is
15   constituted by sliding-block codes for restraining low-frequency components.

    As described above, the code rate and the DC compression are very important factors in the high-density record of data and the reliability thereof when recording the digital data to the record medium, for example the optical record medium, and accordingly more various and improved methods are continuously required to satisfy
20   the factors.

SUMMARY OF INVENTION

    Accordingly, the present invention has been made to solve the foregoing
25   problems of the related art, and it is an object of the invention to provide a method of

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digital data conversion, comprising the following steps of: binding input digital data into unit blocks constituted by a plurality of bytes; modulation-coding each byte of the input data blocks by using a code conversion table; and allocating a merging bit in block unit for the modulation-coded input data in block unit.

5   The present invention further provides a method of digital data conversion, comprising the following steps of: performing 8/15 modulation-coding to an input data block in the unit of m byte and simultaneously producing an RDS of the block in the corresponding order; considering the RDS of the block in the corresponding order and an RDS of the previous block to select a merging bit; and outputting the selected

10   merging bit, following by outputting the encoded block in the corresponding order, and updating the RDS for selection of a merging bit in the next block in order.

          Further, the present invention provides a method of recording and reproducing digital data, comprising the following steps of: binding input digital data into unit blocks constituted by a plurality of bytes and modulation-coding the bytes; allocating a

15   merging bit in block unit for the modulation-coded input data in block unit; recording a byte-unit information expressing the number of the bytes constituting each of the data blocks together with data added with the merging bit after modulation-coding; and performing data decoding for the corresponding block by using the recorded byte-unit information.

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BRIEF DESCRIPTION OF THE DRAWINGS

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          The above objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in

25   conjunction with the accompanying drawings, in which:

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Fig. 1 illustrates a merging process in the EFM coding;

Fig. 2 is a block diagram for illustrating a method of digital data modulation according to the invention;

Fig. 3 is a graph for showing a DC compression when the unit m of one block is varied from 3 to 7 according to the invention; and

Figs. 4A to 4F show digital data modulation code tables according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

A method of converting digital data of the invention comprises the following steps of: binding input digital data into unit blocks constituted by a plurality of bytes; modulation-coding each byte of the input data blocks by using a code conversion table; and allocating a merging bit in block unit for the modulation-coded input data in block unit.

The method of converting digital data of the invention is characterized in that the each of the input data block is bound in the unit of 3 to 7 bytes.

Also, the method of converting digital data of the invention is characterized in that the merging bit allocate in a block unit is constituted by 3 bits.

The method of converting digital data of the invention is also characterized in that each of the modulation-coded input data block is encoded into a code word of a 15 bits length by an 8/15 conversion table.

Further, Also, the method of converting digital data of the invention is characterized in that an RDS of the present input data block is compared to an RDS of the previous input data block to select the merging bit so that the RDS has the minimum

value without violating RLL restraints when the present input data block is produced.

Also, the method of converting digital data of the invention is characterized in that the selected merging bit is primarily outputted, and then the encoded present input data block is outputted and simultaneously an RDS up to the present block is updated to prepare merging bit selection of the next block.

Another method of converting digital data of the invention comprises the following steps of: performing 8/15 modulation-coding to an input data block in the unit of m (wherein m is 3 to 7) byte and simultaneously producing an RDS of the block in the corresponding order; considering the RDS of the block in the corresponding order and an RDS of the previous block to select a merging bit; and outputting the selected merging bit, following by outputting the encoded block in the corresponding order, and updating the RDS for selection of a merging bit in the next block in order.

A method of recording and reproducing digital data of the invention comprises the following steps of: binding input digital data into unit blocks constituted by a plurality of bytes and modulation-coding the bytes; allocating a merging bit in block unit for the modulation-coded input data in block unit; recording a byte-unit information expressing the number of the bytes constituting each of the data blocks together with data added with the merging bit after modulation-coding; and performing data decoding for the corresponding block by using the recorded byte-unit information.

Also, the method of recording and reproducing digital data of the invention is characterized in that each of the input data blocks is modulation-coded and decoded in the unit of 3 to 7 bytes.

Further, the method of recording and reproducing digital data of the invention is characterized in that the merging bit is selected from the merging bits of 3 bit so that the RDS value may not be the minimum while violating RLL restraints.

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Hereinafter more detailed description will be made for embodiments of the invention in reference to the accompanying drawings.

Fig. 2 is a block diagram for illustrating a method of digital data modulation of the invention.

First, merging bits are added in block unit in the invention, in which the blocks are defined as follows.

In defining one input data block 201, m bytes are bound as one unit block.

Herein, m means an input data bundle of at least 2 bytes, preferably 3 to 7 bytes.

Each byte of the input data block is inputted into a modulation encoder 202 and encoded into a code word of 15 bit length by using an 8/15 conversion table (refer to Fig. 4). The result of encoding forms a data block of m X 15bit length (kth block).

The 8/15 conversion table is used to convert the input data, in which the 8/15 conversion table is constituted to have the value of RDS variation as small as possible.

As described before, Running Digital Sum 1 (RDS1) of the kth block is produced simultaneously with encoding each byte of the input data block. A merging bit selector 203 compares RDS1 of the kth block like this to RDS0 of the k-1th block to select the merging bit.

In other words, when the kth block is produced in comparing RDS1 of the kth block to RDS0 of the k-1th block, the merging bit is selected from 000, 001, 010 and 100 so that RDS has the minimum value while the RLL does not violate run-length constraints.

In this case, a merging bit of three bit is used, which is selected taking account of the RDSs of the present block and the next block.

The encoded kth block is outputted (204) after previously outputting the merging bit selected like this, and simultaneously RDS0 up to the kth block is updated to prepare merging bit selection of the k+1th block.

A series of processes like this are repeated to obtain modulated digital data.

5   The modulated digital data are modulated in such a manner that the input data are bound to blocks with the minimum two bytes in unit, and a merging bit is added in a channel data block unit corresponding to each of the input blocks.

In this case, the input data can be bound in three to seven byte unit to execute a merging process in block unit.   Then, a modulation code having 0.5 to 0.5185 code

10   rate can be obtained according to the block size (3 to 7 bytes) of the input data.

Fig. 3 shows a DC control ability when varying the unit m of one block from three to seven.   This shows a result (45:3 merging) in which the three bit input (24 bits) is 8/15 modulation-coded (45 bits) and then added with the merging bit, and the ability is -32dB at the frequency of $0.0001f_c$.

15   Figs. 4A to 4F show an example of the 8/15(2,15) modulation table used in the method of digital data modulation of the invention, in which one conversion table is used for 256 inputs (1 byte) with a status number of four.

As described before, the merging bit is added in block unit in modulating the digital data thereby incurring improvement of the DC compression ability and the code

20   rate.

When the merging bit is added in block unit in modulating the digital data, one block is preferably constituted by binding three to seven bytes.   Therefore, the block is necessarily defined in byte number suitable for the environment of data processing. When an information expressing the number of bytes constituting one block or the

25   number of data constituting a unit block of the added merging bits is recorded together

in recording the modulation data, a merging process and a data decoding can be executed correctly for a corresponding block in decoding by using this recorded information.

In other words, when the digital data are recorded through modulation encoding, n (n is an integer at least 2, for example 3 to 7) byte unit of process data or information is recorded together, a decoder can judge how many bytes constitute a corresponding block by using the information in block unit and accordingly perform data decoding and reproduction suitable thereto.

According to the present invention as described hereinbefore, several input data are bound to define the block unit and the method of adding the merging bits in block unit is used in modulation of the digital data thereby improving the code rate and DC compression ability.

According to the method of data modulation of the invention, the modulated code of the 0.5 to 0.5185 code rate can be obtained according to the block size (3 to 7 bytes) of the input data.

While the invention has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.